P2.9 VORTEX LIFE CYCLES IN QUASI-GEOSTROPHIC FLOWS WITH JETS

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Numerical simulations using QG beta-plane 2- and 3-level models, in flow regimes with dynamically organized westerly jets, exhibit vortex formation similar (given the various simplifications of the model) to the formation of some sub-tropical cyclones and Gulf Stream rings. Through examination of a large number of vortex cycles of birth and death in QG simulations, a view of vortex life-cycles emerges which makes clear the importance of the large-scale flow organization. Our findings emphasize some processes known from earlier studies to play a role in vortex evolution, and de-emphasize others. We find:

1) The primary vortex generation process starts with a breaking Rossby wave traveling on a westerly jet. The breaking wave extrudes a PV filament which rolls up and produces a vortex (sometimes two or even three) at the scale of a few (first) baroclinic deformation radii. Whether or not such roll-up occurs depends on the ambient strain field, making dynamical determination (as opposed, say, to prescription) of this strain field a key issue. In relatively few cases, a vortex was formed from debris resulting from a vortex re-absorbtion event (see below).

2) In this flow regime, although vortex interactions are observed, true vortex merger events are rare. Lifetimes can be quite long, and by far the most common end of a vortex is (re-)absorbtion in a neighboring westerly jet. These findings have analogues in tropospheric observations. There appears to be relatively little change in vortex size throughout its life. Three qualitatively different radial structures were identified and related to details of formation and evolution.

3) Trajectories of vortices are much like ones seen in passive tracer experiments, although isolated and brief pairing events involving mutual advection do occur. The similarity to tracer trajectories indicates that the motion of the vortices is directed by the larger scale eddy field, which eventually sweeps vortices into the zones of sharp PV-gradients corresponding to the westerly jets. Thus an important time scale in the life cycle of these vortices is the mean time for this sweeping. Passive tracer experiments reported in Abstract 9.5 show this to be the large-eddy turnover time.

4) The vertical structure of the vortex depends largely on the vertical structure of the parent filament, hence that of the breaking wave. In a relatively small number of cases the vertical structure was modified (decreased in vertical extent) by encounter with another vortex, or by a glancing encounter with a jet. No substantial evidence was found for the kind of vertical alignment process seen in earlier studies of QG flows without jets.

Vorticity filaments have earlier been recognized as one among several possible seeds for vortices, but the finding that in regimes which support jet formation, virtually all vortices emerge from filaments, and that the filaments are extruded by breaking Rossby waves, seems a useful sharpening of our view. The relative insignificance of merger and vertical alignment in vortex evolution seen here, when compared with findings of studies without jets, is believed to be due to the importance of the sweeping timescale imposed by the large-scale eddies. Vortex processes occuring on timescales longer than this one are precluded by the presence of the same jets that give rise to the vortices.